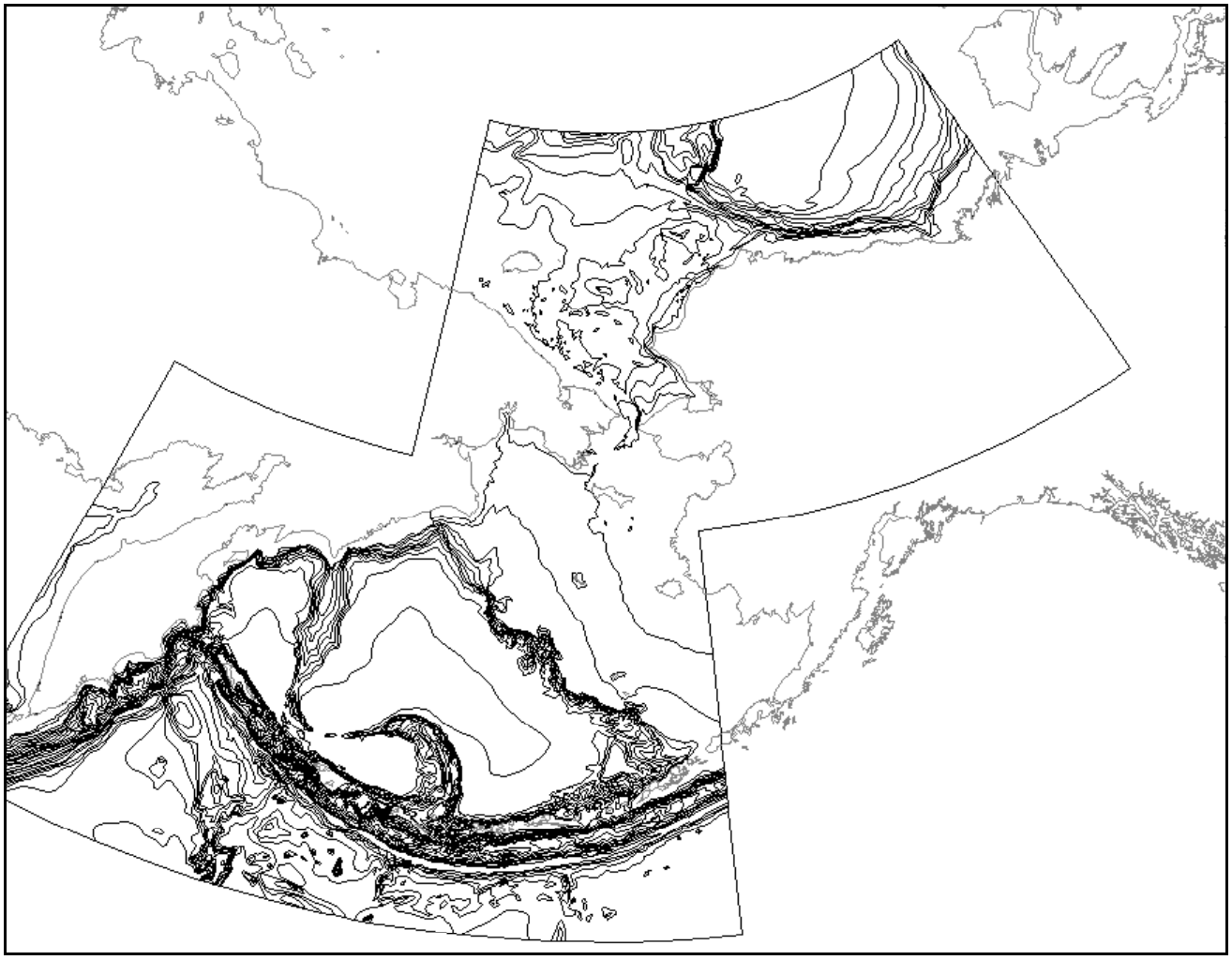
BERING/CHUKCHI SEA ECOSYSTEM DATABASE



Alaska Biological Science Center
Biological Resources Division
United States Geological Survey

July 1997

BERING/CHUKCHI SEA ECOSYSTEM DATABASE

Compiled by
Donna G. Robertson [1]

DATABASE OVERVIEW

The Alaska Biological Science Center (ABSC) of USGS Biological Resources Division has conducted research on marine mammals and birds in the Bering and Chukchi seas since the mid-1980s. This database was created to provide geospatial data on physical and biological characteristics of the Bering/Chukchi ecosystem. It is useful in analyzing the location and movement of animals relative to environmental characteristics.

The report describes the bathymetry and benthic invertebrate portions of the database. These databases are bounded by the western Alaska coast to Point Barrow (155 W longitude) and eastern Russia coast to Wrangel Island (182 E longitude), Aleutian Islands in the south (51 N latitude) and approximately 75 N latitude in the north.

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[1]Present address: Western Ecosystems Technology, Inc., 6705 Lisa Court, Anchorage AK 99516.

BATHYMETRY

BATHYMETRY REQUIREMENTS

Bathymetry is an important parameter in examining marine animal locations and movements. ABSC requirements for bathymetric layers for the Bering/Chukchi Sea Ecosystem Database included high resolution within the continental shelf, knowledge of data sources and data quality control and coverage of large, contiguous regions of the area. The coverages in this database meet these requirements.

BATHYMETRY SOURCES

Bathymetric data from a variety of sources were evaluated, including published paper maps, and point, line, and grid data on CD-ROM.

Paper maps.--The National Ocean Service (NOS), a division of the National Oceanographic and Atmospheric Administration (NOAA), has a complete set of published and blueprint maps for all U.S. coastal waters at 1:250,000 scale. The maps are comparable to USGS topographic maps of the same scale. Depth data for the maps were collected by NOS ships and scientists from the early 1900s to the 1980s. The maps contain bathymetric contours at 10-meter resolution with supplemental contours at 2-meter intervals. NOAA also published nautical charts at varying scales for U.S. waters. Many of these contain a combination of bathymetric contours and point depths. The Strategic Environmental Assessment Division of NOAA published the Bering, Chukchi, and Beaufort Seas Coastal/Ocean Zones Strategic Assessment ("BCB Atlas"), which contains a bathymetric map of the Bering/Chukchi/Beaufort region. The bathymetry map was derived from several map sources and contains no original data.

The USGS produced several bathymetric maps of regions within the Bering/Chukchi Sea area. Data for the maps were collected during mineral and geologic surveys of specific areas. The maps were developed for different projects and purposes, and vary in scale, projection, resolution, and size of area covered.

The Geological Society of America (GSA) published a map of the Arctic Ocean and adjoining seas. Bathymetric contours were derived from a variety of international sources, and no original data were collected for the map. The map is no longer in print and is difficult to find. In addition, GSA published a high resolution map, *Bathymetric Map of the Bering Shelf*, in 1974 which contains 10-meter resolution bathymetry in US and Russian waters. The map was compiled and contoured by NOS, using data collected by NOS, the Hydrographic Office, and the Coast and Geodetic Survey.

The *General Bathymetric Charts of the Oceans* (GEBCO) is an international map series developed with cooperation from multiple countries. Depth data were collected using varying methods by many sources, however the data were reviewed to meet established standards before they were used for generating contours. The maps are at 1:10,000,000 scale with contours at 500-m intervals. Supplemental contours are included at 50, 100, and 200 m where data are available.

Digital Data.--The National Geophysical Data Center (NGDC), a division of NOAA, developed several CD-ROMs that include bathymetric data. The CD-ROM sets are: (1) *NOS Hydrographic Survey Data*, (2) *Marine Geophysical Trackline Data*, (3) *Global Relief*, and (4) *TerrainBase*. The *NOS Hydrographic* CD-ROM contains point data for NOS bathymetry surveys. The data range from highly concentrated points along navigation corridors, coastal areas, and ports, to sparse points in coastal areas without ports, to no data in off-shore waters. The *Marine Geophysical Trackline* CD-ROM contains bathymetric point

data from a wide variety of sources covering a broad area. The tracklines are predominantly off-shore within the continental shelf, complementing the *Hydrographic* CD-ROM, however, the tracklines are sporadic in coverage, and the quality of the data cannot be easily verified. The *Global Relief* CD-ROM contains a variety of marine and terrestrial databases. For bathymetry the CD-ROM contains a gridded database called *ETOPO-5* which contains global bathymetry at 5-minute latitude/longitude resolution. *ETOPO-5* was derived from unpublished 1:5,000,000 scale U.S. Naval Oceanographic Office bathymetric contours. The *TerrainBase* contains data similar to *Global Relief*, including *ETOPO-5*. *TerrainBase* no longer appears on NGDC order forms.

There are two additional sources of digital bathymetric data. GEBCO developed a *Digital Atlas* CD-ROM which contains worldwide bathymetric contours at 1:10,000,000 scale with contours at 500-m intervals. The NOAA World Data Center for Marine Geology and Geophysics is developing techniques for examining the ocean floor using a radar altimeter aboard a satellite. Current radar altimeter technology has low resolution, and is being used to map seamounts and other large topographic features in regions where sounding data are sparse, and as a precursor to ship-board surveys.

Other sources.--Oil companies collected seismic and depth data within the Bering/Chukchi study area. However, these data are proprietary - which would prevent ABSC from redistributing coverages derived from them - and limited in scope. The Defense Mapping Agency (DMA), Department of Defense, also has bathymetric charts. Many DMA charts are classified, and all are difficult to obtain.

BATHYMETRY SELECTED FOR DATABASE

Based on ABSC established requirements, 5 bathymetry sources were selected for the database. All maps were digitized from paper sources, except where noted, to produce Arc/INFO coverages that contain polygons. Each polygon contains the mid-depth between its bounding contours (e.g. the mid-depth between 10 and 20 m is 15 m). Depths for all coverages are in meters. All coverages are stored in geographic projection, to facilitate reprojection as needed by users. Metadata for each coverage contain information in addition to that listed below. Individuals accessing the bathymetry coverages are highly encouraged to examine the associated metadata.

Polygon coverages, rather than grids, were produced for the database because the original map sources were line contour maps and polygon coverages maintain the original integrity of the source contours, and because reprojection errors may occur with grids. When reprojecting coverages in a grid format, some projections delete grid cells, while others may add cells. Therefore, each time a coverage is reprojected, data may be lost or arbitrarily added. Polygon coverages may be converted to grids if desired.

File names for the bathymetry coverages are in three parts: a 7 or 8 letter description of the location of the data or the data source followed by an underscore, the number "3" which indicates polygon topology, and the 3-letter code "geo" which labels the coverages as geographic or latitude/longitude projections.

(Online linkage at **http://www.absc.usgs.gov/research/bering/bathy**)

NOS Bathymetry of U.S. Waters (nosbath_3geo). The highest resolution bathymetry in the database is a coverage digitized from more than 90 NOS maps (Figure 2). Map source resolution is 1:250,000. Point data from the NOS Hydrographic CD-ROM where were used to generate contours in areas where data points were highly concentrated and produced high quality contours that resembled the paper maps. The NOS coverage includes Bristol Bay, the Bering Sea shelf, the Bering Strait, the Chukchi Sea, and the Beaufort Sea. The maps end at the U.S. Exclusive Economic Zone (EEZ), i.e. only U.S. bathymetry. Contours are at 10-m intervals from 0 to 200 m (for budget reasons our coverage ends at 200 m, but the NOS maps contain data to several thousand meters in the Bering and Beaufort seas). Intermediate contours at 2-m intervals were not included in the coverage because the scale was considered too fine for most research needs, and the supplemental lines often ended without polygon closure.

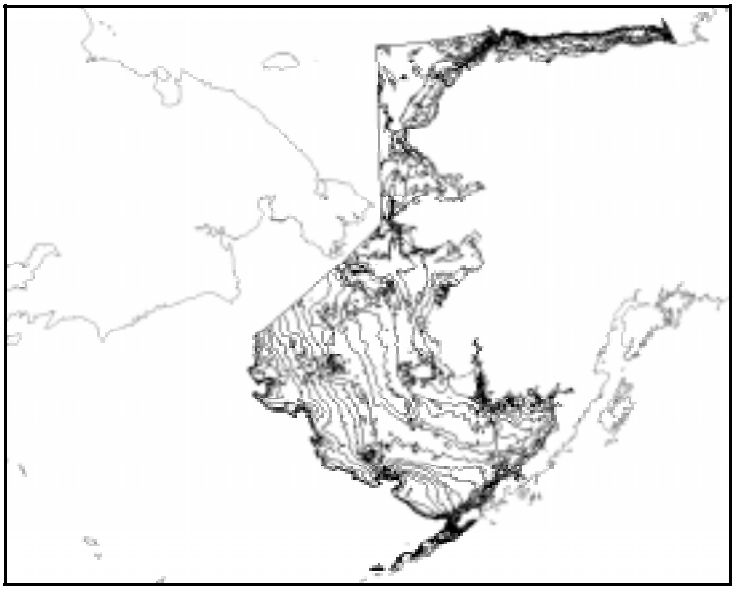

Figure 2. Gif image of bathymetry polygon coverage of National Ocean Service maps. Filename NOSBATH_3GEO.

USGS Chukchi Sea Bathymetry (chukbath_3geo). The Bathymetric Map of the Chukchi Sea (USGS Miscellaneous Investigations Map I-1182-D) contains contours of the Chukchi Sea from Smith Bay, east of Point Barrow, Alaska to Herald Island, east of Wrangel Island, Russia, and ends at the Bering Strait (Figure 3). The resolution is similar to, but slightly lower than, the NOS bathymetry, and contributes the Russian side of the Chukchi Sea. Original map resolution is 1:1,000,000.

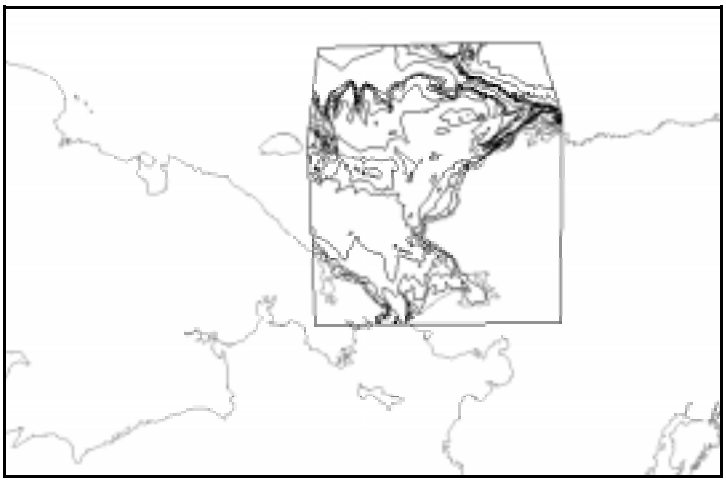

Figure 3. Gif image of bathymetry polygon coverage of U.S. Geological Survey Misc. Investigations Map I-1182-D. Filename CHUKBATH_3GEO.

USGS Bering and Chukchi Sea Bathymetry (berchuk_3geo). Two USGS Open File Report (OFR) maps were joined together to create one coverage of the Bering and Chukchi seas. The Bathymetric Map of the Chukchi Sea and Arctic Ocean (USGS OFR 76-823) is a low resolution map of the Chukchi Sea and southern Arctic Ocean (Figure 4). The resolution is low (1:2,500,000), but contributes contours around Wrangel Island, Russia not found on other maps. The Bathymetric Map of the Aleutian Trench and Bering Sea (USGS OFR 76-821), companion to OFR 76-823, has the same low resolution but contributes bathymetric contours around the entire Aleutian Island chain and on the Russian side of the Bering Sea not otherwise available on a contiguous map (Figure 4).

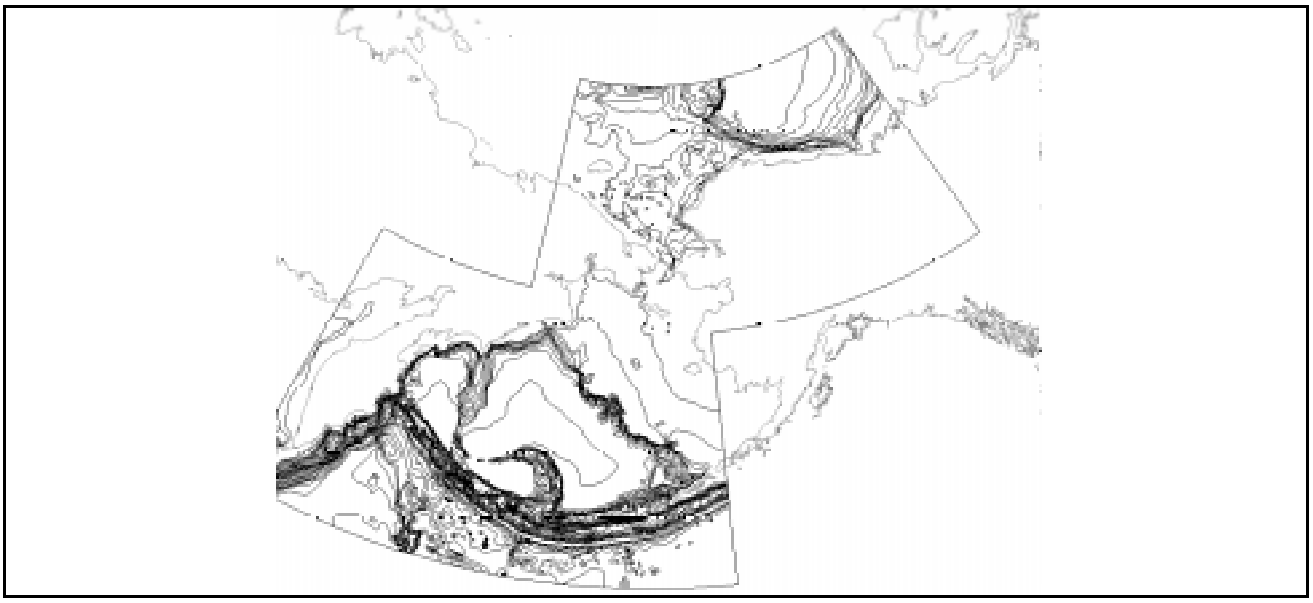

Figure 4. Gif image of bathymetry polygon coverage of U.S. Geological Survey Open File Reports 76-821 and 76-823. Filename BERCHUK_3GEO.

<u>USGS Bering Strait Bathymetry (berstrat_3geo)</u>. The Topographic and Bathymetric Map of the Northern Bering Sea Region (USGS Professional Paper 759-B) contains a small section of the Bering Strait (Figure 5). This map was included because it provides high resolution bathymetry of the Russian side of the EEZ that complements the NOS maps. Source resolution is 1:1,000,000.

Figure 5. Gif image of bathymetry polygon coverage of a map from U.S. Geological Survey Professional Paper 759-B. Filename BERSTRAT_3GEO.

<u>GSA Gulf of Anadyr Bathymetry (anadbath_3geo)</u>. The Bathymetric Map of the Bering Shelf (Geological Society of America 1974) contains bathymetry for Russia in the Bering Strait, Gulf of Anadyr, and north Bering Sea shelf (Figure 6). The map complements the NOS bathymetry, and contours overlap well to about 60 or 70 meters. Sources for the map include data from the Hydrographic Office, NOS, and Coast and Geodetic Survey. This map was included because it provides good resolution bathymetry from quality sources for Russian waters not found on any other source. The line across contours is overlap for merging with NOS bathymetry (nosbath_3geo).

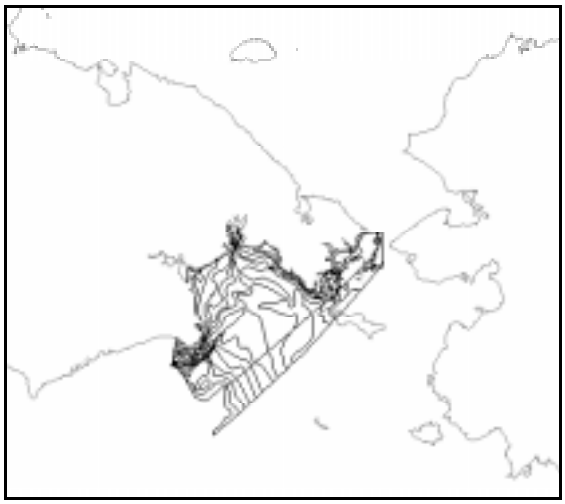

Figure 6. GIF image of bathymetry polygon coverage of Geological Society of America, Bathymetric Map of the Bering Shelf. Filename ANADBATH_3GEO.

WHY OTHER BATHYMETRY WAS NOT SELECTED

There were several reasons why other bathymetric data were not selected for the database. The GEBCO maps and CD-ROM, NOAA charts, and radar altimetry data contained high quality data at a low resolution, with contour intervals too sparse for wildlife research needs. The *GSA map of the Arctic Ocean* and the *BCB Atlas* derived contours from other sources, diluting and altering the original data. The *Marine Geophysical Trackline Data* contained inconsistencies and varied data collection methods that could not be resolved. Bathymetric data from oil companies were not considered because they are proprietary - which would prohibit ABSC from freely distributing the data - and of limited geographic extent. The Defense Mapping Agency maintains the highest quality and resolution charts and maps; however, the maps are either classified, no longer in distribution, or extremely difficult to obtain.

ETOPO-5 was not included directly in the database because it is readily available on the *Global Relief* CD-ROM from NGDC, and since it contains global bathymetry, individual scientists should extract data from selected areas as necessary. In addition, the 5-minute pixel resolution may be too course for many wildlife research applications.

BENTHIC INVERTEBRATE DISTRIBUTION

BENTHIC INVERTEBRATE OVERVIEW

The Bering/Chukchi Sea Ecosystem benthic invertebrate database includes two distinct parts, (1) a literature database and (2) point coverages of benthic invertebrate sampling cruises in Alaskan waters from the National Oceanographic Data Center (NODC). The literature database is a PC-based Paradox database. (Online linkage at **http://www.absc.usgs.gov/research/bering/invert/lit**)

BENTHIC INVERTEBRATE LITERATURE DATABASE

This database contains pertinent information from journal articles, book chapters, and government agency reports. Table 3 lists the fields and field descriptions contained in the literature database as they appear in the printed *Paradox* report.

The literature database is numbered by the field **REF_NO**, which corresponds to the reference number of the article. Database users can examine the database by reviewing the printed *Paradox* report or querying the database. The printed Paradox report contains a one-page synopsis of each article and a map (.gif format) of the geographic extent of research described in the article. (The maps were generated in Arc/INFO using the database fields **SE_LAT**, **SE_LON**, **NW_LAT** and **NW_LON**.) A user wishing to locate articles written on a specific region, taxon, or sampling method can use queries in Paradox to narrow down the number of articles to examine and the number of fields to list.

Table 3. List and description of benthic invertebrate database fields. The Paradox database is part of the Bering/Chukchi Sea Ecosystem Database.

Database Field	Field Description	Database Field	Field Description
REF_NO	Reference number of article, matches reprint number	AUTHOR	Senior author of article
PUB_YR	Year article published	N_AUTH	Number of authors on article
PUB	Name of journal, book, report, or thesis	TYPE	Journal, book, government report, or thesis
C_REF	Reference numbers of other articles that use or refer to the same data	AREA	Generalized size of sample area in square kilometers
SEA	Bering and/or Chukchi Sea	REGION	More detailed description of location
SE_LAT	Southern most latitude of area sampled, decimal degrees	SE_LON	Eastern most longitude of area sampled, decimal degrees
NW_LAT	Northern most latitude of area sampled, decimal degrees	NW_LON	Western most longitude of area sampled, decimal degrees
START	First year data were collected	END	Last year data were collected
SEASON	Month(s) or season(s) when data were collected	GRAB	Yes/no, were grab or core samples taken?
G_SAMP	Number of stations where grab samples were collected	G_SIZE	Size of grab sample
G_REP	Number of replicate samples taken at each station	TRAWL	Yes/no, were trawl samples collected?
T_SAMP	Number of stations where trawl samples were collected	T_WIDTH	Width of trawl net opening
T_MESH	Size of trawl mesh, in millimeters	OTHER	Yes/no, were other methods used to collect samples?
O_SAMP	Number of stations where other methods used to collect samples	N_SPP	Total number of invertebrate species or other taxonomic group collected
ABUND	How abundance presented	TAXON1	Most abundant taxonomic group sampled
TAXON2	Second most abundant taxonomic group	TAXON3	Third most abundant taxonomic group
SP_LIST	How species or taxonomic groups are listed (appendix or table) and thoroughness of list (all or partial)	SIZE	Yes/no, are data on invertebrate size included?
CITATION	Full citation of article	NODC	Yes/no/unknown/maybe, are these data in the NODC benthic organism data file and point coverages
VESSEL	Name sampling platform, useful for tracking between NODC and literature database	TRACKNO	Reference to NODC benthic organism data track number, if known
TRACKNO2	Reference to 2nd NODC track number, if more than one		

NODC POINT COVERAGES OF BENTHIC ORGANISMS

Point data from sampling cruises for fish/shellfish and benthic organism in Alaskan waters were provided by NODC. NODC provides a clearinghouse of ocean sampling data, including fish and invertebrate trawls, invertebrate and sediment cores, and other environmental data. ABSC obtained data for the Bering, Chukchi, and Beaufort seas and the Gulf of Alaska. The data were in two databases, fish/shellfish surveys (F123) and benthic organisms (F132). The fish/shellfish survey data were not designed to sample benthic invertebrates except crabs, and the data were not incorporated into this phase of the invertebrate database.

The NODC data are in Unix compressed ASCII data files (akF123.dat and akF132.dat). NODC divided each benthic organism cruise into 7 layers of information for data storage management. Layers included (1) a single header record for each cruise containing information on when and by whom data were collected, (2) station header records for tow (or trawl) sampling containing a record for each station where data were collected with lat/lon coordinates and sampling methods used at each station, (3) station header records for point (core or grab) sampling containing lat/lon coordinates an sampling methods, (4) environmental records for each station containing weather and sea condition data, (5) bottom characteristics records from each station containing data collected from bottom core samples, (6) taxonomic records from each station containing taxonomic code numbers and weight data for organisms collected during tow and core sampling, and (7) text records for sampling stations containing comments from researchers. The layers for a single cruise are linked together using the NODC track number and station numbers assigned by researchers. The layers incorporated into the invertebrate database include the header layer, the tow and core methods layers, and the taxonomic layer.

Data Import into Arc/INFO.--The data for each sampling cruise were extracted from the ASCII data file and converted to Arc/INFO coverages. Data collected by tow and core sampling were kept separate throughout the data conversion process. The header records and tow and core records were extracted from the ASCII data file and header information was merged with the tow and core sampling station data. The cruises were separated by the NODC track number and the data structure was reformatted to read into INFO attribute tables. The "generate" command in Arc was used to create point coverages from the longitude, latitude coordinates listed for each sampling station. An INFO table template was created and used to import header and station data for each cruise into attribute tables. Arc point coverages and INFO attribute tables were merged together using the "joinitem" command in Arc.

Taxonomic data were extracted from the ASCII data file. As noted above, the taxonomic data layer contained a taxonomic code number instead of a scientific name. The NODC taxonomic code CD-ROM was used to merge scientific names and ranks with the taxonomic codes listed in the data file. Tables 4 and 5 describe the hierarchical structure of the taxonomic code and the 3-letter taxonomic ranks assigned with the code. Please refer to the NODC Taxonomic Code CD-ROM documentation (file name readme.txt) for detailed information about the taxonomic code. The data were separated by NODC track number and the data structure was reformatted to read into INFO attribute tables. An INFO table template was created and used to import the taxonomic data into attribute tables.

Table 4. Example of the structure and content of National Oceanographic Data Center (NODC) taxonomic code. The taxonomic code is used to associate scientific names of benthic organisms sampled in the Bering and Chukchi seas. This example describes the taxonomic lineage for the bivalve *Macoma calcarea*, in the phylum mollusca (taxonomic code 5085). Source: NODC taxonomic code CD-ROM, Version 8.0.

NODC Code	Taxonomic Hierarchy Structure	*M. calcarea* lineage
55	subkingdom, phylum, subphylum, **class**, superorder, or order	bivalvia
5515	superclass, class, subclass, superorder, **order**, suborder, infraorder, section, or superfamily	veneroida
551531	class, order, suborder, or **family**	tellinidae
55153101	**genus**	Macoma
5515310101	**species**	*Macoma calcarea*

Table 5. Three-character abbreviations used to describe the hierarchical rank in the National Oceanographic Data Center (NODC) taxonomic code for kingdom Animalia. The codes are used in taxonomic INFO attribute tables of benthic organism sampling in the Bering and Chukchi seas. Source: NODC taxonomic code CD-ROM documentation.

Rank	**Description**	**Rank**	**Description**
KNG	kingdom	COH	cohort
PHY	phylum	GRB	group b
SBP	subphylum	IFO	infraorder
SPC	superclass	SEC	section
CLS	class	DIC	division c
SBC	subclass	SPF	superfamily
IFC	infraclass	FAM	family
DIV	division	SBF	subfamily
DIA	division a	SPT	supertribe
SDA	subdivision a	GEN	genus
IFD	infradivision	SBG	subgenus
SPO	superorder	GRC	group c
SER	series	SPE	species
ORD	order	SSP	subspecies
SBO	suborder		

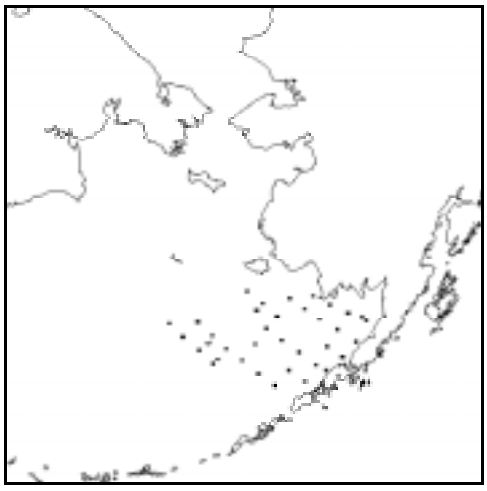

Figure 7. National Oceanographic Data Center point locations for cruise TR3268. Data were collected by tow and core in 1976.

Figure 8. National Oceanographic Data Center point locations for cruise TR3269. Data were collected by tow in 1976.

All point coverages and INFO attribute tables are named according to the NODC track number. Several articles in the literature database correspond to data in the NODC benthic invertebrate database. These are identified by the NODC track number. At least two reports state that their data are on file with NODC or that they acquired their data from NODC, some of these data appear to be missing from ABSC's version of the NODC database. In addition, the literature database is missing articles that correspond with several of the NODC cruises. Nine of the 71 tow cruises and 6 of the 31 core cruises were conducted in the Bering and/or Chukchi seas, these are printed in Figures 7 - 15.

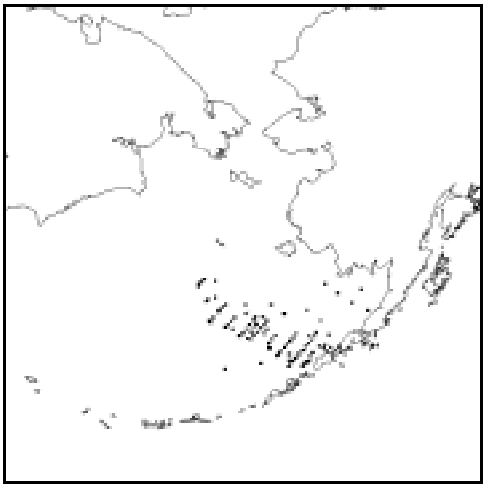

Figure 9. National Oceanographic Data Center point locations for cruise TR2111. Data were collected by tow in 1976.

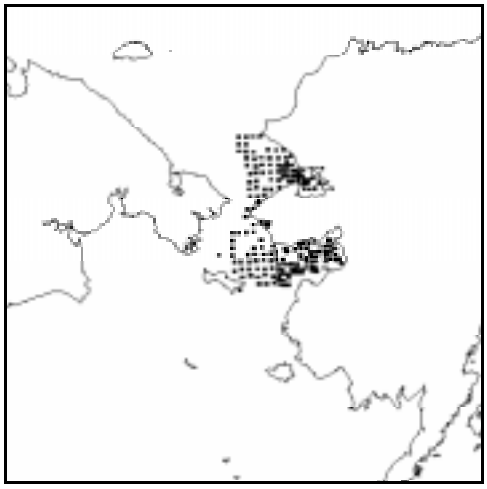

Figure 10. National Oceanographic Data Center point locations for cruise TR2836. Data were collected by tow in 1976.

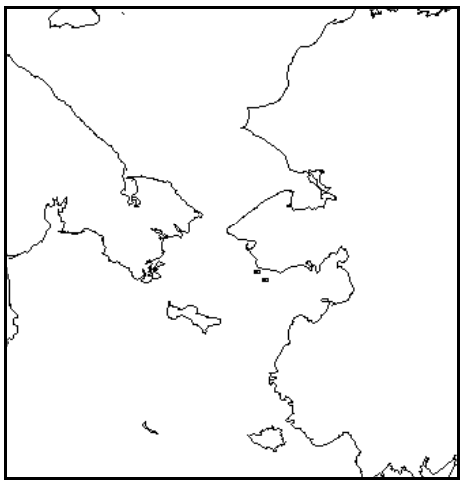

Figure 11. National Oceanographic Data Center point locations for cruise TT1798. Data were collected by tow and core in 1979.

Figure 12. National Oceanographic Data Center point locations for cruise TV4231. Data were collected by tow and core in 1987.

Figure 13. National Oceanographic Data Center point locations for cruise TT1799. Data were collected by tow and core in 1980.

Figure 14. National Oceanographic Data Center point locations for cruise TV4232. Data were collected by tow and core in 1986.

Figure 15. National Oceanographic Data Center point locations for cruise TV4233. Data were collected by tow and core in 1987.

Using the NODC Point Coverages.--The NODC benthic invertebrate coverages are stored in Unix-format directories on ABSC workstation Gulo. (*No online access at this time.*). Coverages from tow (trawl) and core (core or grab) cruises are stored in separate subdirectories (tow and core, respectively). Taxonomic data collected at each point are stored as INFO tables in the taxa subdirectory. The point coverages can be listed at the Unix prompt by typing the "lk" command (without quotes), and in an Arc session by typing the "lc" (list coverages) command at the Arc prompt. Attributes for sample points can be listed in an Arc session by typing "list <cover>.pat" at the Arc prompt. In an INFO session, attributes can be listed by selecting the table (SEL <COVER>) and typing LIST at the <ENTER COMMAND> prompt. The taxonomic data are in INFO tables with no associated coverage, the names of taxonomic tables can be listed in an INFO session by typing "DIRECTORY" at the <ENTER COMMAND> prompt. INFO stores the tables using an internal name, and using the Unix "lk" command will display the internal names rather than the NODC track numbers. The taxonomic data can be listed in an INFO session as above. Table 6 lists the items and item descriptions in the tow, core, and taxa INFO attribute tables.

Table 6. List and description of attribute items included in Arc/INFO point coverages of benthic organism sampling cruises from the National Oceanographic Data Center (NODC). The database is divided into subdirectories for trawl and core data collection methods and taxonomic data. The taxonomic data can be related to the tow and core sample points using the coverage name (NODC track number) and the STATION field. The Arc point coverages and taxonomic INFO attribute tables are part of the Bering/Chukchi Sea Ecosystem Database, and are stored on Alaska Science Center Workstation GULO.

Item Name	Field Contents Description	Field Contents if No Data
Tow Sampling		
<COVER>#	internal number assigned by Arc	always contains a number
<COVER>-ID	internal number assigned by	always contains a number
POINT_N	sequential point number assigned by	always contains a number
TRACKNO	unique cruise or data set identifier assigned by NODC	always contains a track number
VESSEL	survey platform name	NONE GIVEN
STRDATE	start date of cruise, yymmdd	999999
ENDDATE	end date of cruise, yymmdd	999999
INVESTIG	investigating scientist or other data	NONE GIVEN
AGENCY	name of investigator's agency or	NONE GIVEN
STATION	code identifying a fixed location, date, and time where data collected	NONE
LAT	latitude of station in decimal degrees, always north	always contains a latitude
LON	longitude of station in decimal degrees, always west	always contains a longitude
DATE	date at start of tow, yymmdd	999999
TIME	time at start of tow, hhmm	9999
EQUIP	3-character code describing tow	UNK
TOWDIR	'toward' direction of tow in whole	999
TOWTIME	length of time of tow, hours to	999
STRTDEPT	depth to bottom at start of tow, whole meters	9999
ENDDEPTH	depth to bottom at end of tow, whole meters	9999
WIRELNTH	length of winch wire, whole meters	9999
WIREANGL	angle of winch wire, whole degrees from vertical	99
SEQNO	ascending numeric used to order records within each station	9999
Core Sampling		
<COVER>#	internal number assigned by	always contains a number
<COVER>-ID	internal number assigned by	always contains a number
POINT_N	sequential point number assigned by	always contains a number
TRACKNO	unique cruise or data set identifier assigned by NODC	always contains a track number
VESSEL	survey platform name	NONE GIVEN
STRDATE	start date of cruise, yymmdd	999999
ENDDATE	end date of cruise, yymmdd	999999
INVESTIG	investigating scientist or other data	NONE GIVEN
AGENCY	name of investigator's agency or	NONE GIVEN
STATION	code identifying a fixed location, date, and time where data collected	NONE
LAT	latitude of station in decimal degrees, always north	always contains a latitude
LON	longitude of station in decimal degrees, always west	always contains a longitude
DATE	date core or grab taken, yymmdd	999999
TIME	time core or grab taken,	9999

EQUIP	1-character code for method of sample collection	Z
SCREEN	smallest mesh size of sieve used, millimeters to hundredths	9999
COREAREA	surface area of core or grab, square meters to thousandths	9999
COREDEP	depth of penetration of core or grab, centimeters to tenths	9999
VOLUME	total volume of all replicates sampled, liters to tenths	9999
N_REPS	total replicates at this station which make up sample volume	99
STAT_ID	10-character originator station identifier	NONE
SEQNO	ascending numeric used to order records within each station	9999

Taxonomic Data

POINT_N	sequential point number assigned by	always contains a number
TRACKNO	unique cruise or data set identifier assigned by NODC	always contains a track number
STATION	code identifying a fixed location, date, and time where data collected	UNK
SAMPLE	unique sample identifier assigned by the originator within each station	99999
REPLICAT	unique replicate identifier within each sample &/or station	99
CORESEG	unique identifier for each segment in a core for each replicate sample	9999
NODC_CODE	2-12-digit code to identify taxon using NODC taxonomic code	NOT GIVEN
N_INDIV	total number of individuals of taxon for sample unit measured	0
QUAL_COD	1-character code to describe taxon quality for count & weight measures	U
WET_WET	total wet weight of individuals, grams to thousandths	999999999
ASH_WT	total ash-free weight of individuals, grams to thousandths	999999
COREC_WT	difference between wet and ash-free weight, grams to thousandths	999999
DATE_WT	date of weighing of sample, yymmdd	999999
SEQNO	ascending numeric used to order records within each station	9999
TAX_NAME	taxonomic name associated with nodc_code	NO NAME ON NODC LIST FOR THIS NUMBER
CCD	1-character control code describing type of taxonomic record	Z
RANK	3-character abbreviation of taxonomic rank for taxonomic	ZZZ

The primary purpose of the NODC database is to examine benthic invertebrates recorded at sampling stations within the Bering/Chukchi Sea region. To do this, the point coverages and taxonomic INFO attribute tables must be linked together. **Arc/INFO** requires a one-to-one match between points and point attributes to permanently join them into a coverage. For example, each station in a cruise contains a latitude/longitude coordinate that matches a one-line set of attributes noting when, by whom, and how data were collected at the station. The taxonomic data have many attribute records associated with each point (i.e. many different organisms were collected at one station). Two options were considered for associating taxonomic data with sample point locations. One option was to write a long string of taxonomic data on one line for each station (e.g. species1, weight1, species2, weight2, ... , species*n*, weight*n*) and use the Arc command "joinitem" to permanently merge the taxonomic data with point locations for each cruise. The second option was to leave data for each species as individual records and use "relates" in **Arc/INFO** to temporarily link the data with the point locations. Because the organisms collected were often keyed to different taxonomic levels, and because of the large amount of data involved, the latter option was selected for associating points and data. Below are brief instructions and examples for establishing and using relates in **Arc/INFO**. For more detailed instruction use Arc's online help by typing "help" (without quotes) at the **Arc**, **Arcplot**, or **Arcedit** prompts. Locate the *Master Contents, Working with Tables* chapter and examine the *Managing Your Tabular Data* section.

Subheadings most important for using relates are *The Relate Environment* and *Attribute Query And Logical Selection*.

The example was written to relate the point coverage and INFO attribute table from the NODC track number TV4233.

(1) At the Arc prompt establish a relate between the core point coverage tv4233 and the matching taxonomic INFO table in the taxa subdirectory. Notes: 1. The point coverage is not specified in this step. 2. The example shows the syntax for identifying a relate table in a different subdirectory.

Commands

Arc: relate add (Arc opens the following dialog)
Relation name: name used to identify and access the relate
Table identifier: names taxonomic INFO table to access
Database name: info
Item: item in point coverage that relates to info table
Relate column: item in info table that relates to coverage
Relate type: linear (sort in any order) or ordered (sorted by relate column)
Relate access: rw (read/write), ro (read only), or auto
Relation name: name next relate or use carriage return <cr> to end
Arc: {enter next Arc command}

Example

Arc: relate add
Relation name: taxatv4233
Table identifier: ../taxa/tv4233
Database name: info
Item: station
Relate column: station
Relate type: linear
Relate access: rw
Relation name: <cr>
Arc:

(2) List attribute items from the point coverage and the related table. Attribute items from the relate tables are always referred to using the relate name, followed by double slashes (//), followed by the attribute item. Note: Arc establishes a one-to-one match with the first row encountered for each station. The one-to-multiple match will be established in Arcplot.

Commands

Arc: list <cover>.pat {item} {item} {relate//item} {relate//item}

Example

Arc: list tv4233.pat station taxatv4233//tax_name taxatv4233//rank

```
Record station tax...//tax_name tax..//rank
     1 30      THREADWORMS      PHY
     2 34      RHYNCHOCOELA     PHY
     3 36      THREADWORMS      PHY
     4 39      FORAMS           ORD
```

(3) In Arcplot, use the taxonomic INFO table used in the relate as a "keyfile" (Arcplot's term for a related INFO table) for selecting subsets of the taxonomic data.

Commands

Arc: ap
Arcplot: mapextent <cover> (sets map extent to study area on screen)
Arcplot: points <cover> (displays sample points on screen)
Arcplot: pointtext <cover> {item} (displays the value of 'item' next to the sample points)
Arcplot: list <cover> point {item} {item} (shows a list of selected attribute items from the point coverage)
Arcplot: list <keyfile> info {item} {item} (shows a list of selected attribute items from the taxonomic INFO table)
Arcplot: reselect <keyfile> info {item} <logical operator> {item value} (selects a defined subset of the INFO table)
Arcplot: list <keyfile> info {item} {item} (lists the selected subset of attribute items from the INFO table)
Arcplot: reselect <cover> point keyfile <keyfile> {item} (selects a subset of the point coverage based on the selected subset in the INFO table)
Arcplot: list <cover> point {item} {relate//item} (lists the selected subset of the point coverage with related items in a one-to-one match
Arcplot: clearselect (clears all selected subsets to begin a new selection)

Example

Arc: ap
Arcplot: mapextent tv4233
Arcplot: points tv4233
Arcplot: pointtext tv4233 station (displays the station numbers on screen next to sample points)
Arcplot: list tv4233 point station date (lists stations and dates sampled)
Arcplot: list ../taxa/tv4233 info station tax_name (shows a complete list of species collected at each station)
Arcplot: reselect ../taxa/tv4233 info nodc_code lk '55*' (selects all nodc_code values that start with 55, the class bivalvia)
Arcplot: list ../taxa/tv4233 info station tax_name (lists all the bivalves collected by station)
Arcplot: reselect tv4233 point keyfile ../taxa/tv4233 station (selects the subset of stations where bivalves were collected)
Arcplot: list tv4233 point station taxatv4233//tax_name (lists selected subset of stations where bivalves were collected and the first taxonomic name for each station)
Arcplot: clearselect

(4) Other relate commands allow listing and deleting relates, and saving relate environments for future Arc sessions.

Commands

Arc: relate save <info_file> (saves the current relates to an INFO file, or updates the file if it already exists)
Arc: q
<Unix> arc
Arc: relate restore <info_file> (reads a set of saved relates into the current Arc session)
Arc: relate list (lists relates in the current relate environment)
Arc: relate drop (Arc opens a dialogue)
Relation Name: <relate_name>
Relation Name: <relate_name> or <cr> to end
Arc:

Example

Arc: relate save taxa
Arc: q
<Unix> arc
Arc: relate restore taxa
Arc: relate list
Relate Name: TAXATV4233
Table: ../taxa/tv4233
Database: info
. . . (includes more lines)
Arc: relate drop
Relation Name: taxatv4233
Relation Name:
Arc:

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